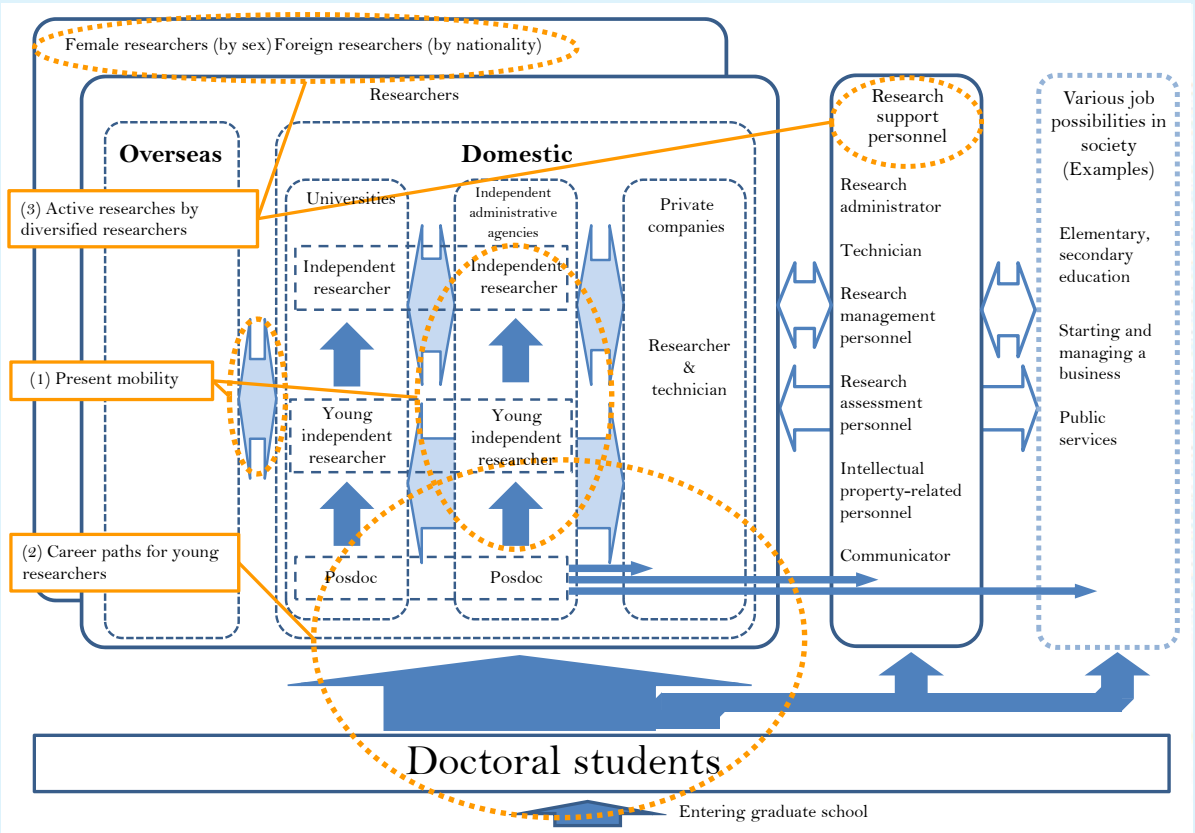
Section 2 The Current Situation Regarding Human Resources in Science, Technology and Innovation

Several viewpoints are possible for understanding Japan's current situation regarding human resources in science, technology and innovation (Figure 1-1-2). These human resources are divided into the categories of "students," "researchers" and "research support personnel," in order to clarify the situation. Researchers are further distinguished according to three characteristics: affiliation (i.e., at a university, a public research institution including an independent administrative institution, or a private company in Japan or overseas), position (i.e., postdoc, young independent researcher in a tenure-track[1] or other position, or independent researcher), and gender/nationality. Based on these classifications, the overall situation is first understood in terms of the number and the age breakdown of these human resources. Then, the current situation is analyzed in detail from the following three viewpoints: 1) the mobility of researchers who move to and from organizations in Japan or overseas, 2) the career paths available to doctoral students[2] and postdocs and 3) opportunities for diverse human resources to play active roles irrespective of gender and nationality.

Figure 1-1-2 / Overview of the Human Resources in Science, Technology and Innovation



Source: MEXT

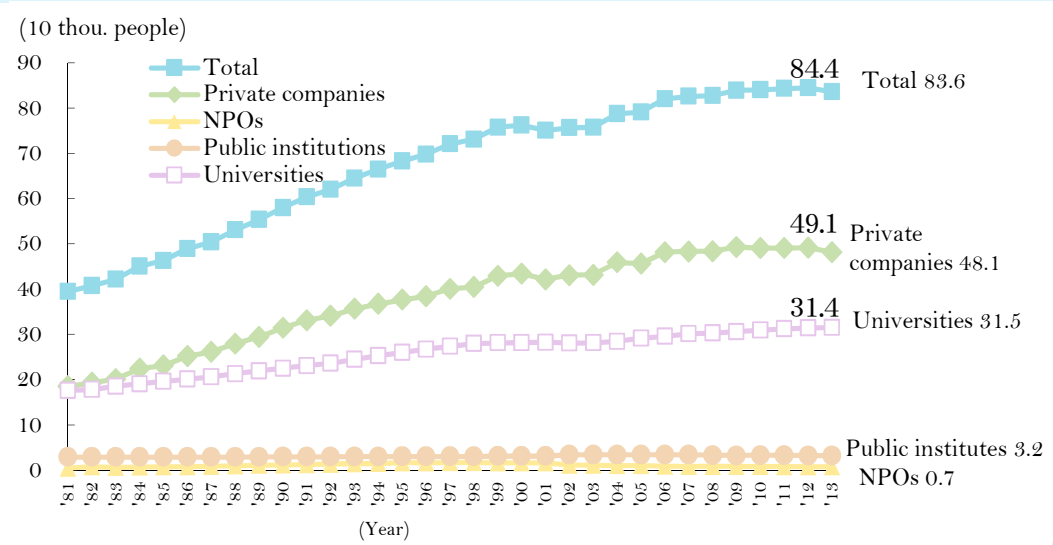
1 Refer to Chapter 2, Section 2-2 for details of the Tenure-Track System.
2 In Part 1, "doctoral courses" refers to doctoral programs, including the third, fourth and fifth year of the five-year program for the doctoral course, and to the four-year program for a Ph.D. in medical, dental or veterinary science, unless otherwise annotated. "Master's courses" refers to master's degree programs and to the two-year first term of the doctoral programs (including the first and second year of the five-year program for the doctoral course).

1 Overall Situation (Number and Age Breakdown of Researchers)

(1) The number of researchers

Researchers in Japan have not been increasing, partly due to the recent economic stagnation. After exceeding 800,000 in 2006, the number of researchers remained roughly flat until 2013, when the number stood at 836,000, which marked a decrease from 844,000 in 2012(Figure 1-1-3). This suggests that the number of researchers has plateaued.

Figure 1-1-3 / Changes in the Number of Researchers in Japan

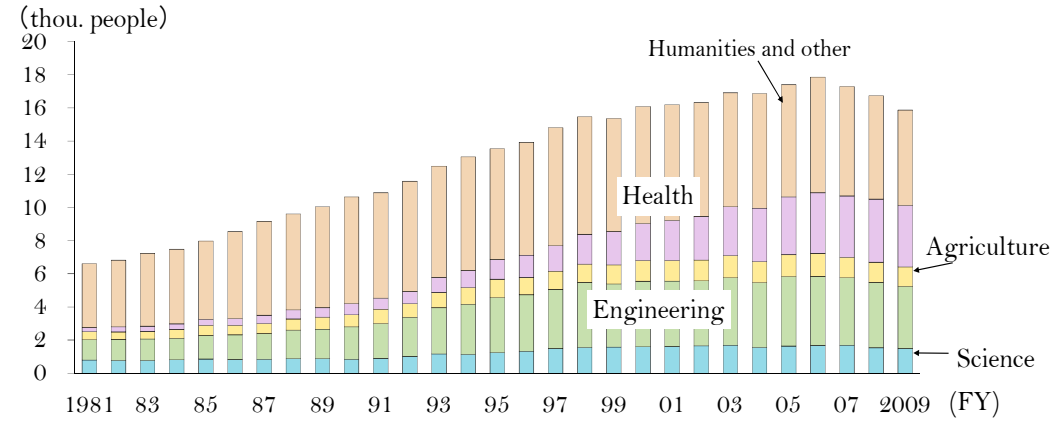


Source: MEXT based on MIC, *Report on the Survey of Research and Development*

(2) The number of doctoral degrees awarded

Although the number of doctoral degrees awarded increased significantly each fiscal year after the quantitative expansion of graduate education programs in the 1990s, it has been gradually decreasing in recent years (Figure 1-1-4).

Figure 1-1-4 / Changes in the Number of Doctoral Degrees Awarded

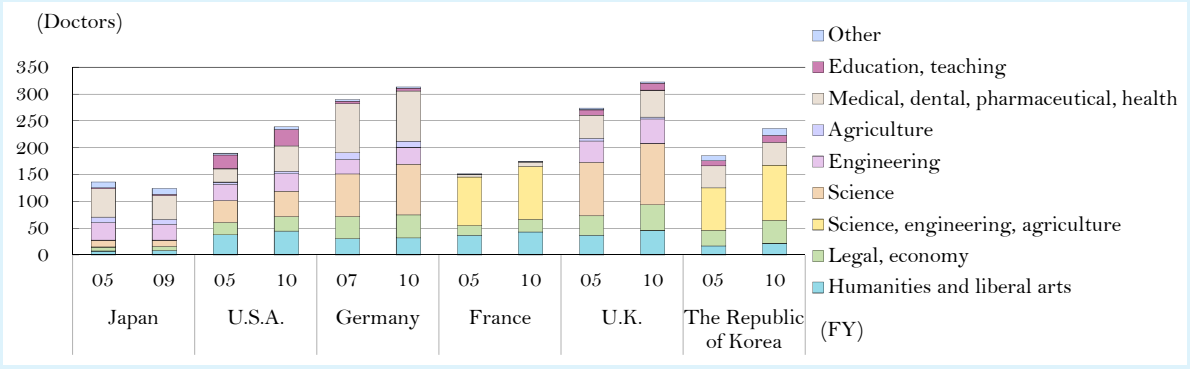


Notes: 1. "Health" refers to medical, dental, pharmaceutical and health sciences.
2. "Other" refers to education, arts and home economics.

Source: NISTEP, *Japanese Science and Technology Indicators 2013*, Survey Material 225 (August 2013)

An international comparison of doctoral degrees awarded per million population shows that the number in Japan is much smaller than in other countries: about half that for the USA and less than half that for the U.K. and Germany (Figure 1-1-5).

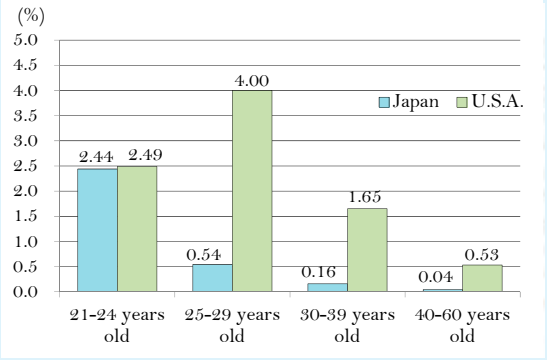
Figure 1-1-5 / Doctoral Degrees Awarded per Million Population



Source: NISTEP, *Japanese Science and Technology Indicators 2013*, Survey Material 225 (August 2013)

Regarding the age of people entering graduate school, those 25 years of age or older account for a lower percentage in Japan than the USA. These data indicate that the number of doctoral degrees awarded is smaller in Japan than in other countries, partly because Japanese students who take jobs after graduating from university are unwilling to go back to school for further learning (Figure 1-1-6).

Figure 1-1-6 / Graduate School Enrollment Rate by Age in Japan and the USA



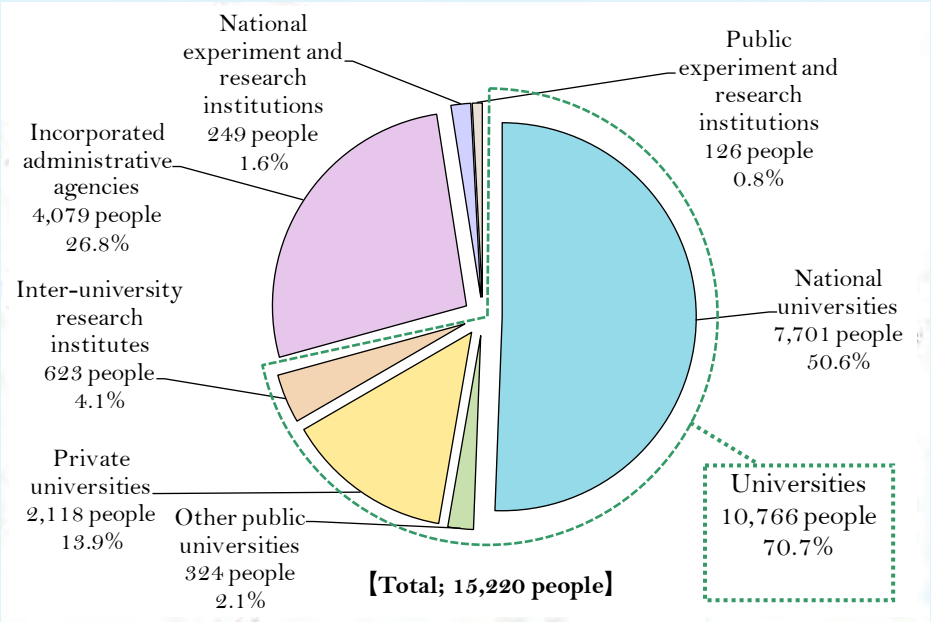
Note: For the USA, the "40-60" age bracket includes those 40-64 years of age.
Source: Extract from Motohisa Kaneko. July 2008. "Outlook of Adult Graduate Students" in *Recruit College Management*, vol. 151, p.6.

(3) Postdoc and other

After obtaining doctorates, postdocs improve their research abilities while working as researchers employed under fixed-term contracts. Before establishing themselves as independent researchers, these postdocs develop their skills through competition with each other under the appropriate guidance of supervisors. Through the experience of working at diverse research institutions, postdocs can expand the range of their research.

In Japan, efforts to increase the number of postdocs started in the late 1990s. As of November 2009, the number of postdocs[1] stood at 15,220[2] (Figure 1-1-7). The *Fiscal 2013 School Basic Survey* shows that of the 16,445 doctoral graduates, 1,855 went on to become postdocs[3].

Figure 1-1-7 / The Number of Postdocs and Their Affiliations

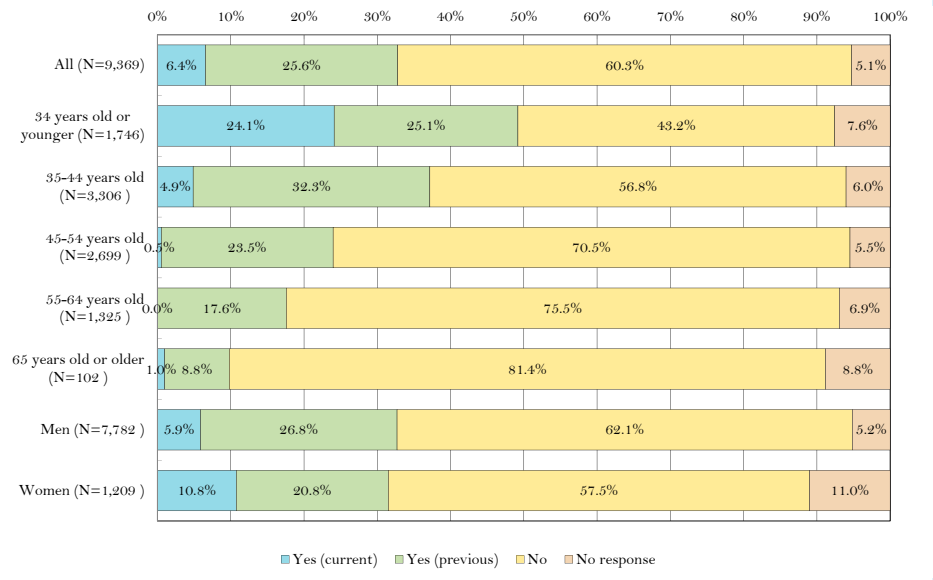


Source: NISTEP Postdoctoral Employment/Career Path Study, Survey Material 202 (December 2011)

Research conducted by the National Institute of Science and Technology Policy (NISTEP)[4] shows that about 30% of researchers in Japan have worked as postdocs and that nearly 50% of researchers 34 years of age or younger were a postdoc at least once (Figure 1-1-8). These data suggest that the postdoc position has become recognized as a career option which a young researcher goes through before they obtain a permanent position.

1 "Postdocs" are those who have obtained a doctorate and are employed under fixed-term contracts. They are either 1) those who engage in research at a university or a research institution but are not a professor, associate professor, assistant professor or associate, or 2) those who engage in research at a research institution such as an incorporated administrative institution but are not a leader or chief scientist of the research group to which they belong.
2 Postdocs mentioned in the NISTEP, *Postdoctoral Employment/Career Path Study* include those who left school after having studied for a standard doctoral course term or longer and have earned the credits required for graduation (so-called "leavers without degrees after fulfilling the required course").
3 Doctoral graduates mentioned in the MEXT *School Basic Survey* include those who left school after having studied for a standard doctoral course term or longer and have earned the credits required for graduation (so-called "leavers without degrees after fulfilling the required course").
4 The National Institute of Science and Technology Policy was reorganized in July 2013, and now it is usually called NISTEP. The name NISTEP is used below to refer to this institute.

Figure 1-1-8 / Experience in Working as a Postdoc

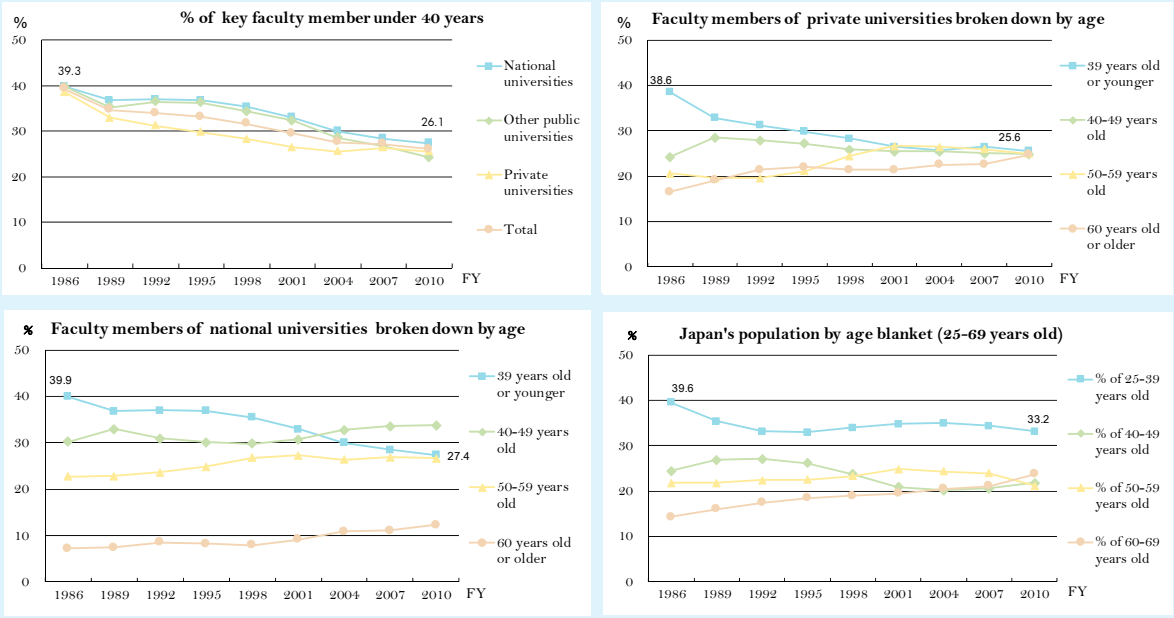


Source: "A Survey about Mobility of Researchers and Diversity of Research Organizations," *NISTEP Report No. 123* (March 2009)

(4) Age breakdown of researchers at universities and public research institutions

In the age breakdown of key faculty members at universities (i.e., professors, associate professors, lecturers, assistant professors and associates who are affiliated with universities regardless of fixed-term or unfixed-term contracts), the percentage of those who are 39 years of age or younger was about 40% in FY1986, but it decreased to less than 30% in FY2010. In light of the age structure of Japan's population, the percentage of researchers 39 years of age or younger is disproportionally small, while the percentage of researchers 40-59 years of age is relatively large (Figure 1-1-9). As these figures show, older key faculty members have been accounting for an increasing share of key faculty members, and the number of positions available to young researchers has been decreasing year by year.

Figure 1-1-9 / Changes in Key Faculty Members of Universities Broken Down by Age



Source: Estimated by NISTEP based on the MEXT *Survey on Staff Statistics*

Regarding researchers working at independent administrative institutions that specialize in R&D[1], the percentage of researchers 37 years of age or younger decreased from FY2007 through FY2010. The percentage of young researchers who hold full-time positions under unfixed-term contracts has decreased significantly (Table 1-1-10).

Accordingly, as in the case of key faculty members at universities, positions available to young researchers have been decreasing at independent administrative institutions as well.

Table 1-1-10 / Young Researchers at Independent Administrative Institutions: Numbers and Share

Fiscal Year	FY2007	FY2010
Researchers	14,690	14,931
Full-time	12,535	12,888
Non-fixed-term	9,584	9,475
Of which young researchers	2,160	1,698
(%)	(22.5%)	(17.9%)
Fixed-term	2,951	3,413
Of which young researchers	1,826	2,039
(%)	(61.9%)	(59.7%)
Part time	2,155	2,043
Of which young researchers	1,206	1,088
(%)	(56.0%)	(53.3%)

Note: "Young researchers" means those 37 years of age or younger at the end of each business year.
Source: MEXT based on Cabinet Office, Government of Japan "*Research Results Regarding S&T Activities in Independent Administrative Agencies and National University Corporations*" (FY2007 & FY2010)

1 National Institute of Information and Communications Technology, National Research Institute of Brewing, National Institute of Radiological Sciences, National Research Institute for Earth Science and Disaster Prevention, National Institute for Materials Science, RIKEN, Japan Agency for Marine-Earth Science and Technology, Japan Aerospace Exploration Agency, Japan Atomic Energy Agency, National Institute of Health and Nutrition, National Institute of Occupational Safety and Health, Japan, National Institute of Biomedical Innovation, National Agriculture and Food Research Organization, National Institute of Agrobiological Sciences, National Institute for Agro-Environmental Sciences, Japan International Research Center for Agricultural Sciences, Forestry and Forest Products Research Institute, Fisheries Research Agency, National Institute of Advanced Industrial Science and Technology, Public Works Research Institute, Building Research Institute, National Traffic Safety and Environment Laboratory, National Maritime Research Institute, Port and Airport Research Institute, Electronic Navigation Research Institute, and National Institute for Environmental Studies (26 corporations in total).

(5) Independent situations of researchers at universities and public research institutions

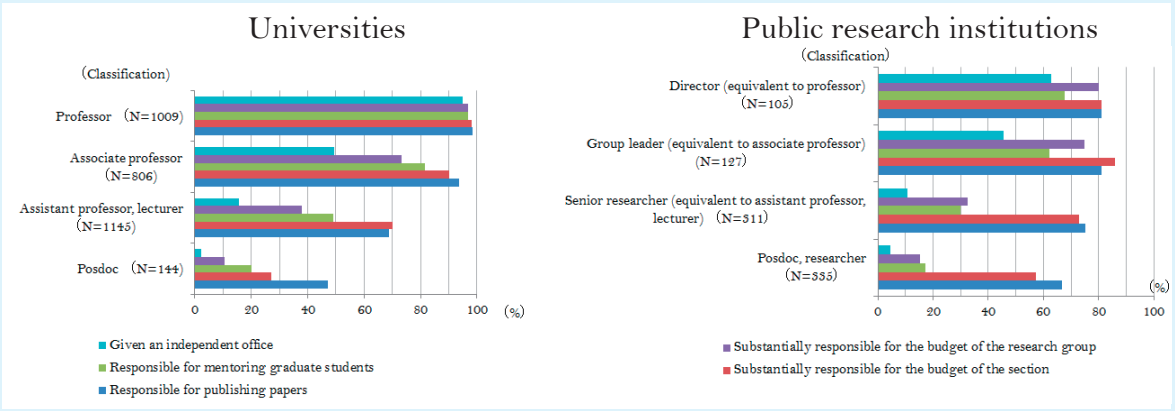
A survey conducted by NISTEP in March 2011 for the purpose of understanding the situation of academic career paths shows the current research environment and degree of authority of researchers by position classification (Figure 1-1-11).

This survey suggests that research environments that allow for autonomy are not secured for researchers in various positions. For example, the percentage of postdocs and research fellows who are corresponding authors of published scientific papers is less than 70% at public research institutions and less than 50% at universities respectively. Only 70% of young researchers (assistant professors, lecturers and chief scientists of research groups) are the corresponding author of a published scientific paper or are the de facto leader in budget-making and project implementation. Regarding associate professors and research group leaders, who are principal investigators, about half are put in charge of their own laboratory.

To bring out the best in researchers, it is critical to respect the ideas of each researcher regardless of age and position, and to leave research activities to the discretion of researchers. The survey results suggest that a hierarchical research system remains in place at universities and public research institutions in Japan and that a flat, non-hierarchical structure for conducting research tends not to be the norm.

On the other hand, because adequate guidance and advice need to be provided to these young researchers by experienced senior or mid-career scientists, it is necessary to ensure not only a flat structure for the implementation of research but also a system for providing appropriate guidance and advice to those young researchers.

Figure 1-1-11 / Degree of Independent situations of Researchers by Position Classification



Note: Researchers specializing in natural sciences only
Source: MEXT based on *NISTEP Independence Processes of Researchers at Universities and Public Research Institutions in Japan, Survey Material 195* (March 2011)

2 Mobility of Researchers

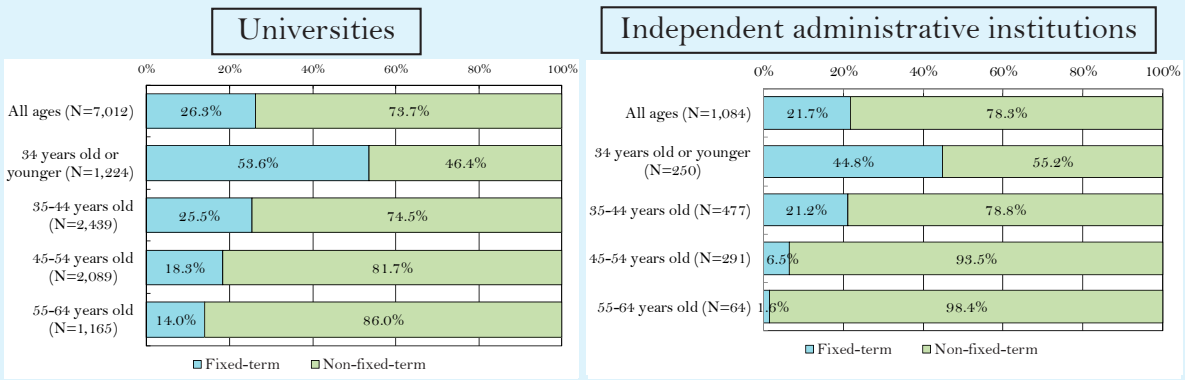
(1) Mobility under the current employment system

1) Fixed-term appointments of researchers at universities and public research institutions

The First Science and Technology Basic Plan (approved by the Cabinet on July 2, 1996) provided for the introduction of a fixed-term system to facilitate the mobility of researchers. Based on this basic plan, an

increasing number of universities and public research institutions have adopted a fixed-term appointment system that targets young researchers. Summarized survey results published by NISTEP in March 2009 show that nearly half of the researchers 34 years of age or younger are employed under a fixed-term appointment system (53.6% at universities and 44.8% at independent administrative institutions) (Figure 1-1-12).

Figure 1-1-12 / Researchers at Universities and Independent Administrative Institutions Who are Employed under a Fixed-term Appointment System, Broken Down by Age

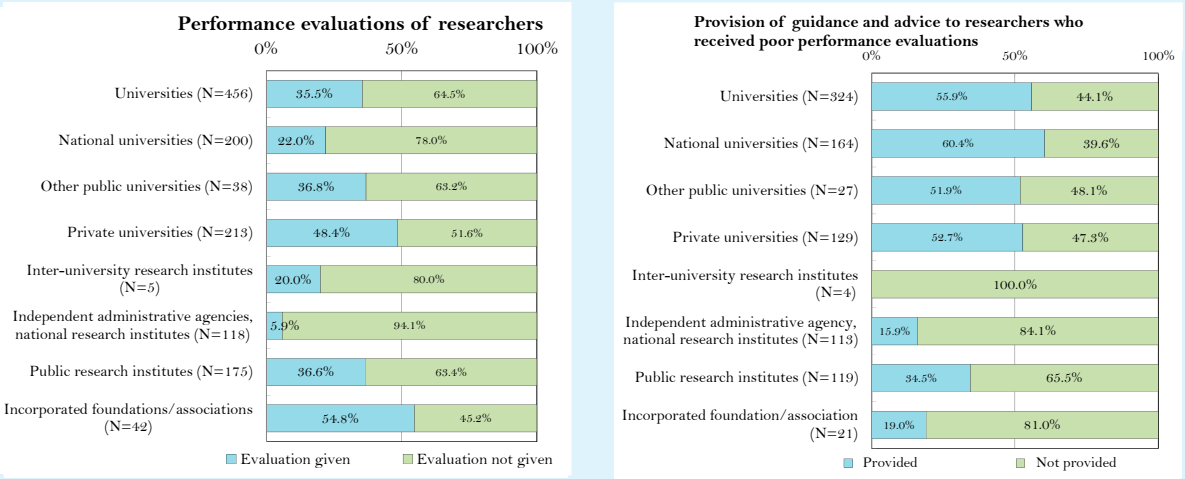


Note: Researchers were grouped into age brackets as of the date of the survey.
Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

2) Evaluation and treatment of researchers at universities and public research institutions

The ways in which researchers are evaluated and treated have a great deal to do with the researchers' mobility (Figure 1-1-13). A survey conducted by NISTEP shows that 64.5% of universities and 94.1% of independent administrative institutions and national research institutions perform evaluations of researchers. While more than 80% of the independent administrative institutions and national research institutions provide guidance necessary for the improvement of researchers who have been given poor performance evaluations, over half of the universities provide no such guidance.

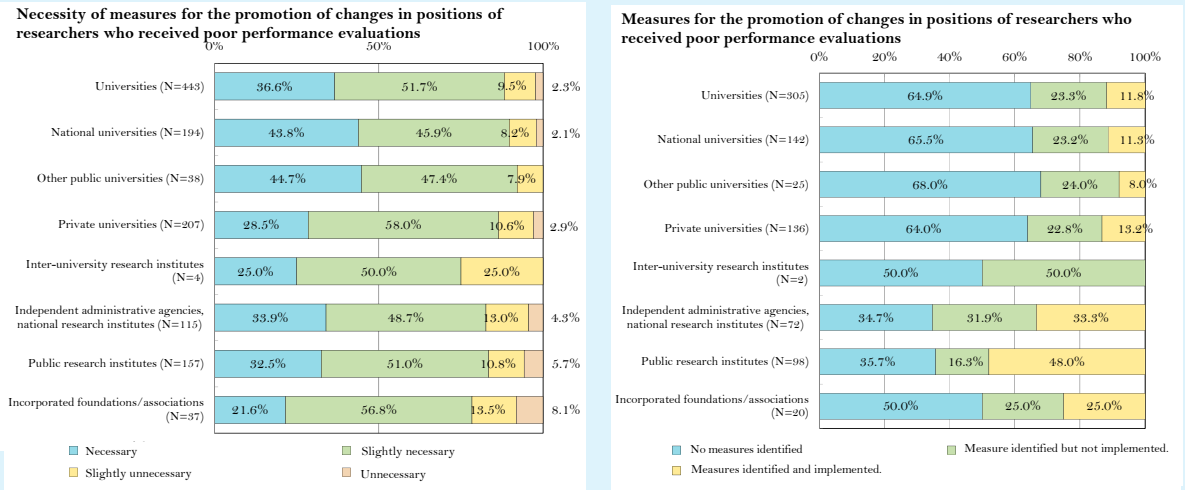
Figure 1-1-13 / Current Situation Regarding Performance Evaluations Given to Researchers



Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

A survey was also conducted regarding the awareness and implementation of measures for initiating the change in position of researchers with poor performance. The survey shows that more than 80% of universities, independent administrative institutions, and national research institutions are aware of the need to initiate researchers' changes in position. For this survey, 64.9% of the universities responded that they had no measures for initiating changes in position, and only 11.8% of the universities responded that they had measures in place and were implementing them. Concerning independent administrative institutions and national research institutions, 33.3% responded that they had measures in place and were implementing these measures, and 34.7% responded that they had no measures (Figure 1-1-14).

Figure 1-1-14 / Awareness and Implementation of Measures for the Initiating of Changes of Position for Researchers with Poor Performance



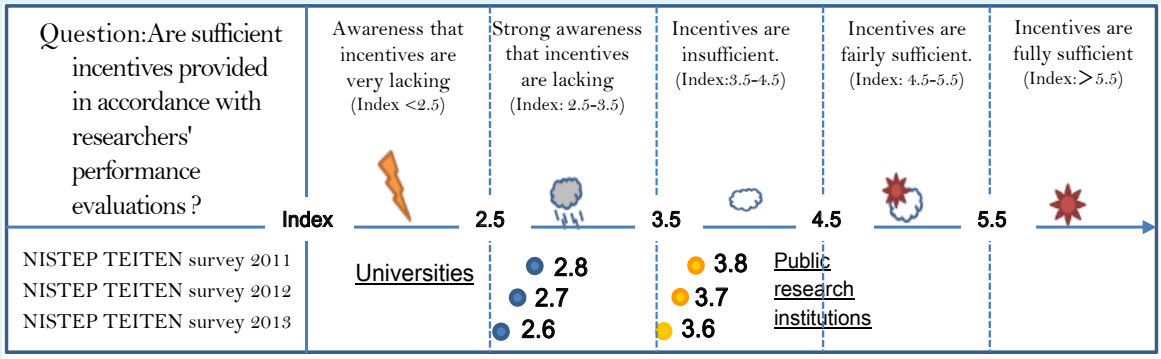
Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

As part of the survey, respondents were asked to freely describe the measures they were taking, and many of them responded that they reassigned researchers with poor performance ratings to other sections. It seems that universities capitalize on the fixed-term appointment system when making personnel changes. Many of the respondents referred to the "scarcity of positions available for moving researchers to" and "problems associated with employment contracts" as factors that made it difficult for them to change the positions of researchers with poor performance. This result suggests that enhanced overall mobility, diversification of career paths and utilization of fixed-term appointment systems are the keys to using research performance evaluations in changing the positions of researchers.

The NISTEP TEITEN survey[1] shows that research performance evaluations do not provide sufficient incentives, and that the index value regarding the availability of incentives, which is calculated on the basis of scores given by the respondents, is decreasing every year (Figure 1-1-15).

1 This is a NISTEP Expert Survey that is conducted every fiscal year of about 1,500 researchers and experts in government, industry and academia with the aim of understanding the situation pertaining to science, technology and innovation in Japan in terms of the availability of research funding and the diversity of basic studies and the like, which are hard to understood from conventional R&D statistics. Responses to the survey in the form of scores are converted to index values from 0 to 100; thus, it is easy to understand the awareness of the current situation by researchers/experts as well as yearly changes in this awareness.

Figure 1-1-15 / Awareness of Incentives Provided to Researchers on the Basis of Performance Evaluations (Expert Survey Results)



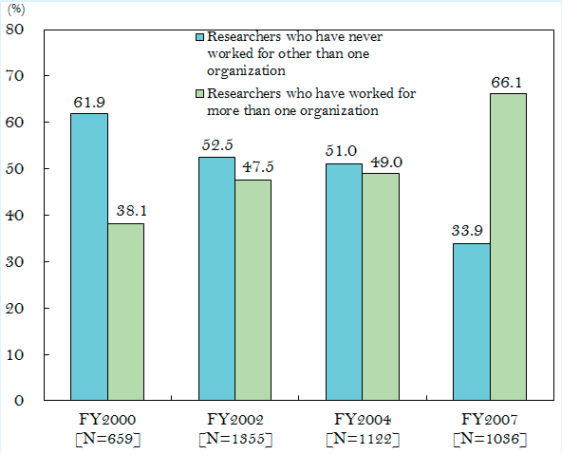
Source: MEXT based on NISTEP, *Expert Survey on Japanese S&T System and S&T Activities by Fields* (2013 NISTEP TEITEN survey) (April 2014)

(2) Mobility within the country

1) Experience of moving to a different position

A survey by NISTEP and MEXT shows that the percentage of researchers in the private sector and academia who have moved to different positions was 66.1% in FY2007, and the percentage has continuously increased since FY2000, according to the similar surveys conducted by MEXT for FYs 2000, 2002 and 2004 (Figure 1-1-16).

Figure 1-1-16 / Changes in the Percentage of Researchers Who Report Having Moved to a Different Position



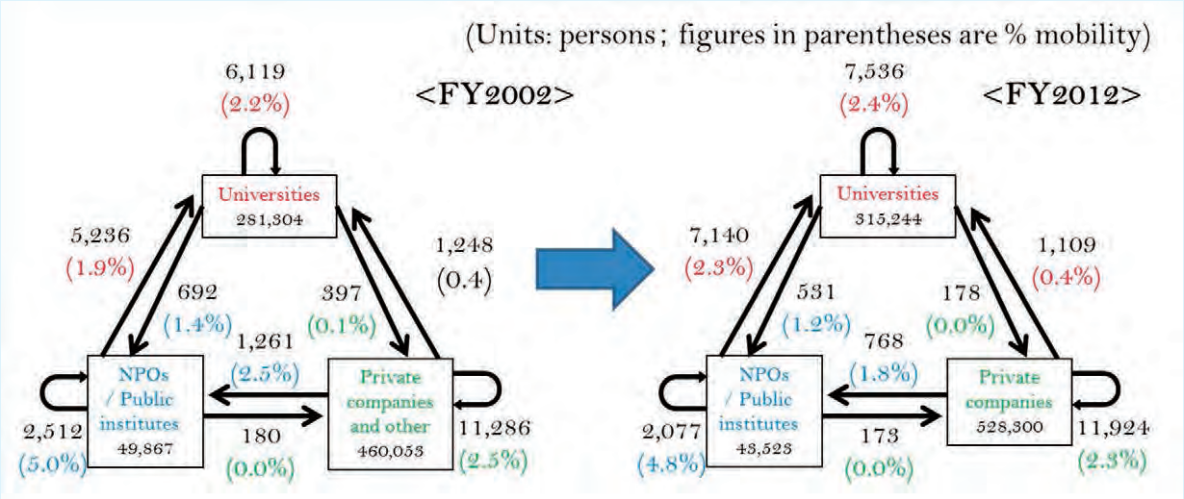
Source: NISTEP & MEXT, *Survey on Mobility of Science and Technology Researchers in Japan*, Survey Material 163 (January 2009)

The respondents to this survey have moved to a different position 1.32 times on average. Changes of position average 1.53 times for doctoral degree holders, indicating that they moved more than researchers without doctorate degrees, who change positions an average of 1.07 times. Of these doctorate degree holders, researchers who had worked as postdocs changed position more (2.65 times) than those who had not worked as postdocs (1.22 times). These data show that doctorate degree holders, particularly those who have worked as postdocs, have much greater mobility than other researchers. This result is likely to be associated with the situation in which the majority of postdocs who are initially employed under fixed-term contracts then move to a different workplace to obtain a position.

Next, the mobility of researchers between sectors (i.e., universities, enterprises, non-profit organizations and public research institutions) is reviewed according to the MIC Survey of Research and Development. This survey shows that the percentage of researchers moving within or between sectors has remained low

and almost unchanged for ten years, although slightly more researchers moved from non-profit organizations and public research institutions to universities in 2012 than in 2002. Researcher mobility is particularly low between universities and private companies (Figure 1-1-17).

Figure 1-1-17 / Mobility between Sectors

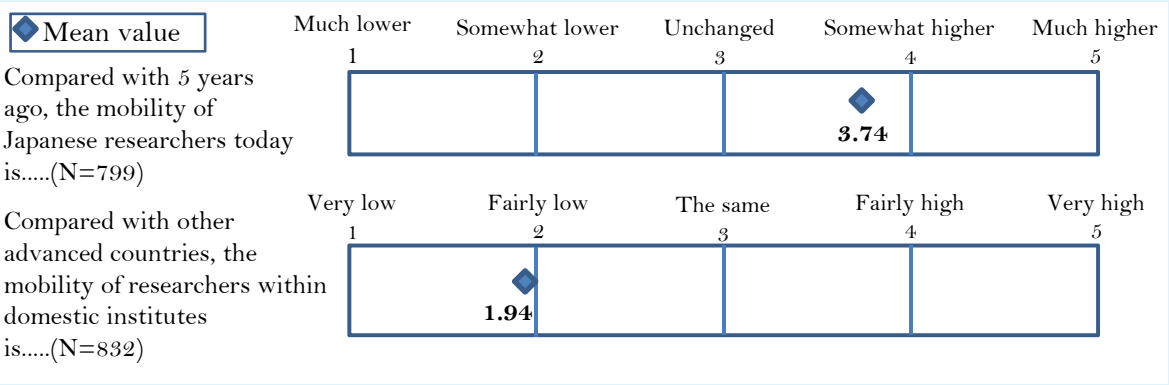


Note: Mobility was calculated by dividing the number of researchers who reported moving to a given sector by the number of researchers (the head count) in that sector.
Source: MEXT based on MIC, *Survey of Research and Development*

2) Perceptions of researcher mobility

A survey conducted by NISTEP and MEXT regarding researchers' perceptions shows that researcher mobility in Japan has increased in the past five years but is still lower than in other advanced countries (Figure 1-1-18).

Figure 1-1-18 / Researchers' Perceptions of Human Resource Mobility in Japan

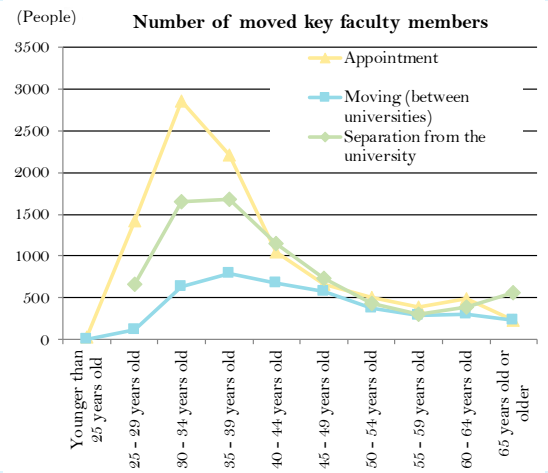


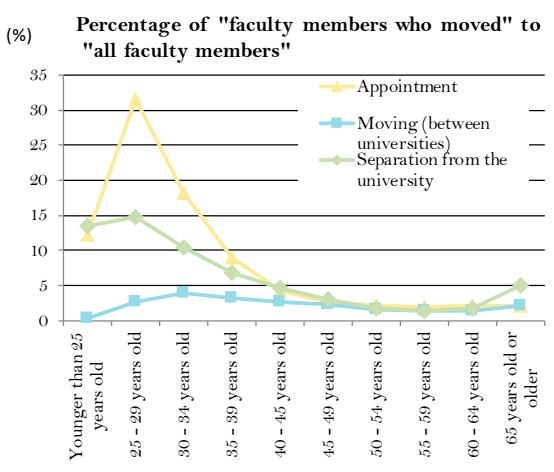
Source: NISTEP & MEXT, *Survey on Mobility of Science and Technology Researchers in Japan, Survey Material 163* (January 2009)

3) Mobility broken down by age

The mobility of researchers at universities and public research institutions is reviewed according to age bracket (Figure 1-1-19). First, the mobility of key faculty members at universities is examined according to age bracket in terms of changes in the numbers of those who were newly employed, who moved to a different university or who left their jobs. Mobility peaks in the 30-34 age bracket. The percentage of people who are employed, moved to a different university or quit their jobs in the total key faculty members peaks in the 25-29 age bracket. Both the mobility and the percentage decrease as the researchers become older.

Figure 1-1-19 / Mobility of Key Faculty Members at Universities, Broken Down by Age

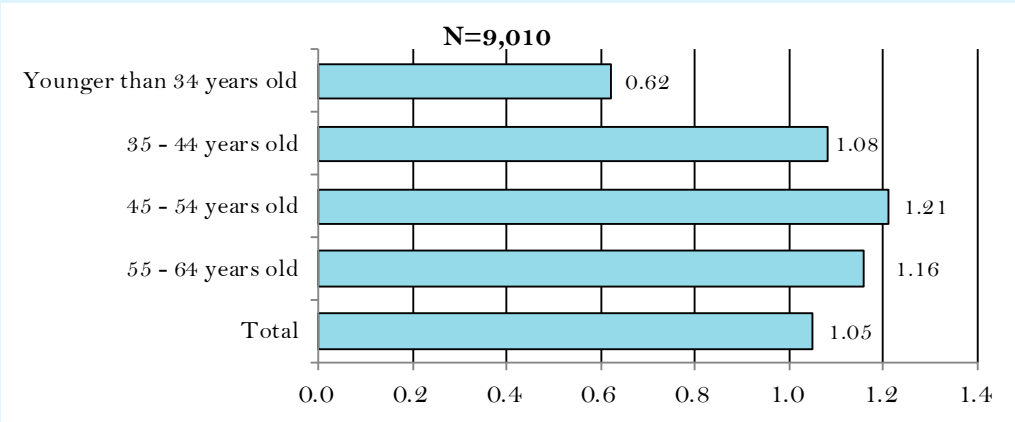




Source: MEXT base on *Survey on Staff Statistics* (FY2010)

Survey results summarized by NISTEP in March 2009 regarding researchers at universities and public research institutions (Figure 1-1-20) show that researchers 34 years of age or younger changed positions 0.62 times on average. The figure is higher (1.08 times) for the age 35-44 bracket but is not much higher in the upper age brackets.

Figure 1-1-20 / Frequency of Change in Position, Broken Down by Age

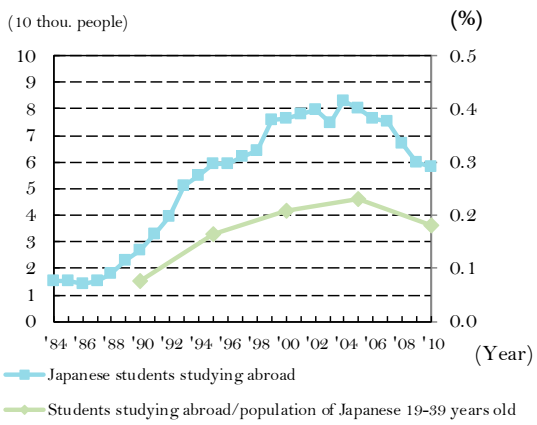


Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

(3) Global mobility

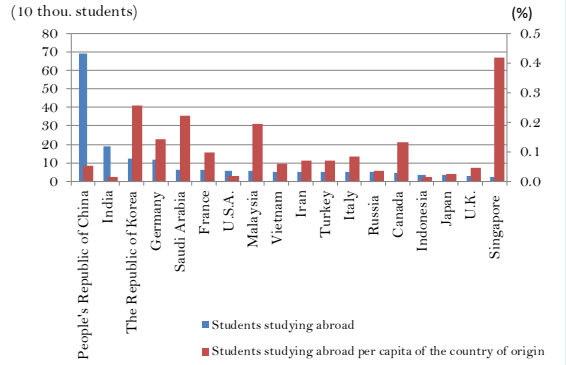
It is often mentioned recently that young Japanese are introverted and inward-looking. The total number of Japanese students studying abroad has been decreasing since its peak in 2004, and the percentage of Japanese students studying abroad in the 19-39 age bracket has also been decreasing (Figure 1-1-21). In comparison with major countries, fewer Japanese students study abroad both in terms of number of students and per capita (Figure 1-1-22).

Figure1-1-21 / Changes in the Number of Japanese Students Studying Abroad



Source: MEXT based on OECD, *Education at a Glance*, UNESCO, Institute for Statistics' data, IIE *Open Doors*, data collected by the Ministry of Education of the People's Republic of China, data collected by the Ministry of Education Republic of China, and MIC, *National Census*

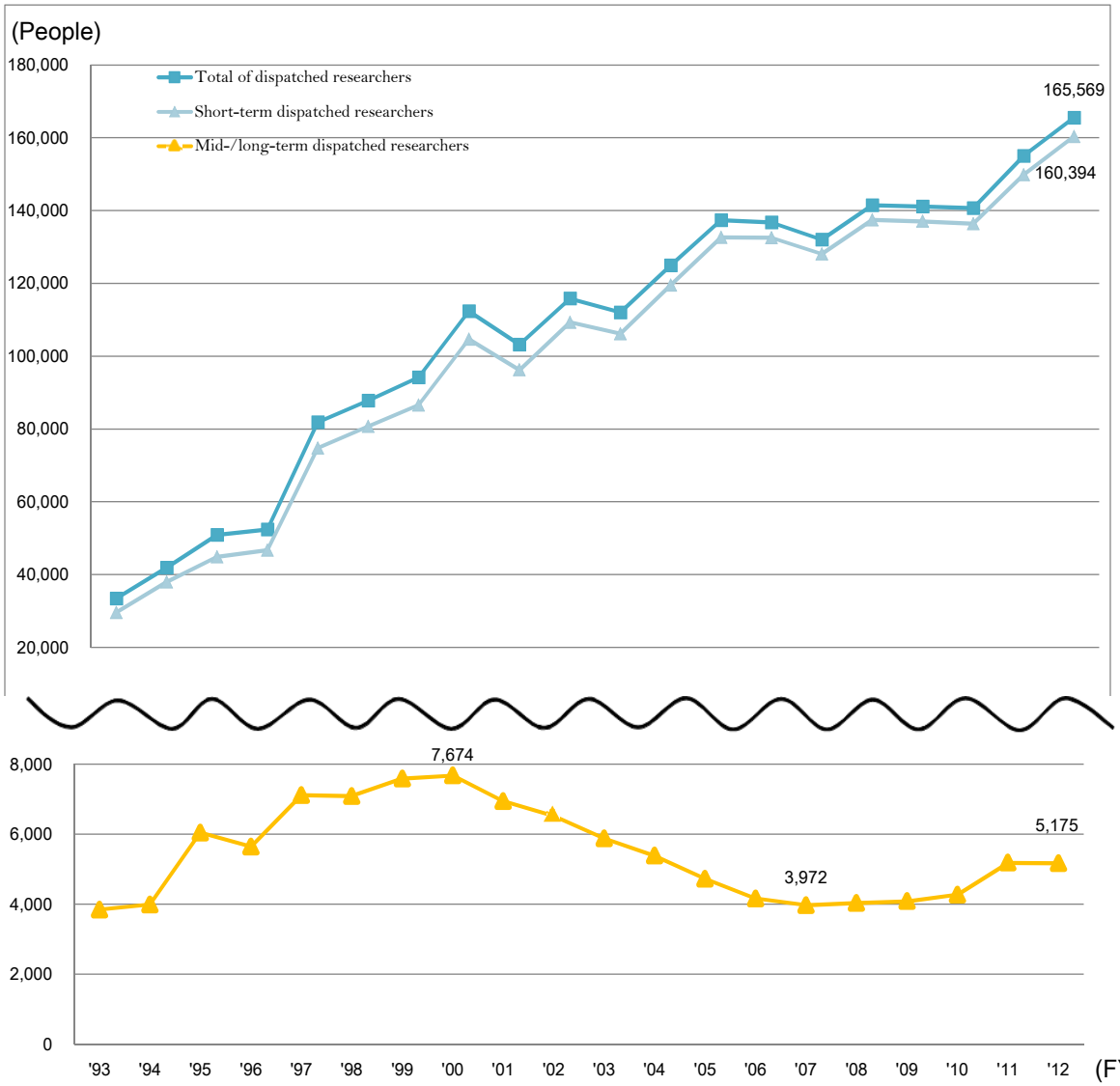
Figure 1-1-22 / The Number of Students Studying Abroad by Country of Origin



Source: MEXT based on UNESCO Institute for Statistics, *Global Flow of Tertiary-level Students* (as of the end of March, 2014) and WHO, *World Health Statistics 2013*

The current situation regarding researchers at universities or public research institutions who are sent overseas for study/research is described (Figure 1-1-23). The number of researchers sent overseas for short terms (30 days or less) has been continuously increasing. In contrast, the number of researchers sent overseas for medium or long terms (longer than 30 days) decreased continuously from FY2000, when it peaked at 7,674 people, declining to 3,972, about half of the peak, in FY2007. In the last few years, the number has been increasing, but it remains at about 70% of the peak.

Figure 1-1-23 / Changes in the Number of Japanese Researchers Sent Overseas



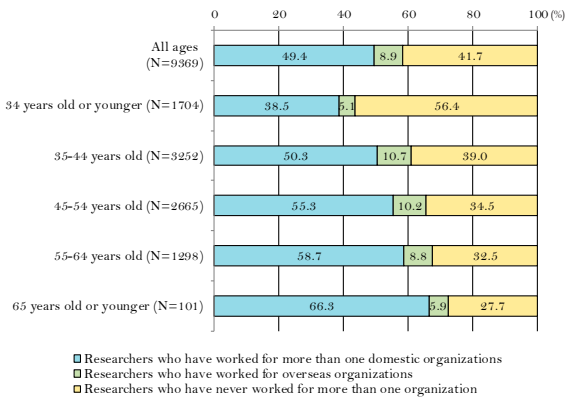
Notes: 1. In this survey, "Mid-term/long-term" refers to a period of more than 30 days and "short-term" refers to a period of 30 days or less.
2. "Researchers sent overseas" includes postdocs from FY2008 and research fellows from FY2010. It is not known whether postdocs and/or research fellows were included among researchers in the surveys conducted in and before FY2007.
Source: MEXT, *Survey on International Research Exchanges* (April 2014)

A survey conducted by NISTEP shows that only 8.9% of researchers at universities or a public research institutions have worked as a paid research overseas. More than 90% of researchers have not engaged in research in other countries (Figure 1-1-24).

Under these circumstances, networking with international researchers is not yet sufficient in Japan.

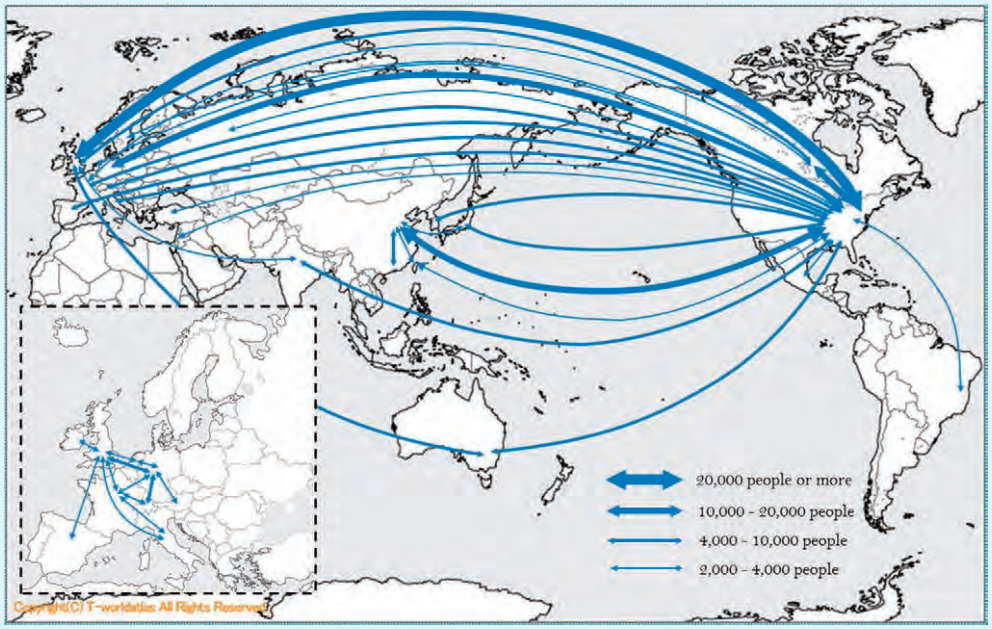
For instance, a survey about the international mobility of researchers conducted by the Organization for Economic Co-operation and Development (OECD) indicates that the USA is playing a central role in the global network. Researchers in European countries follow in terms of international mobility. Specifically, many researchers in the U.K., Germany and France go to the USA, and those in the USA go to one of these European countries for research. This shows that Research institutions in Japan are mostly outside the network of international research institutions (Figure 1-1-25).

Figure 1-1-24 / Experience of Having Worked as a Paid Research Overseas



Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

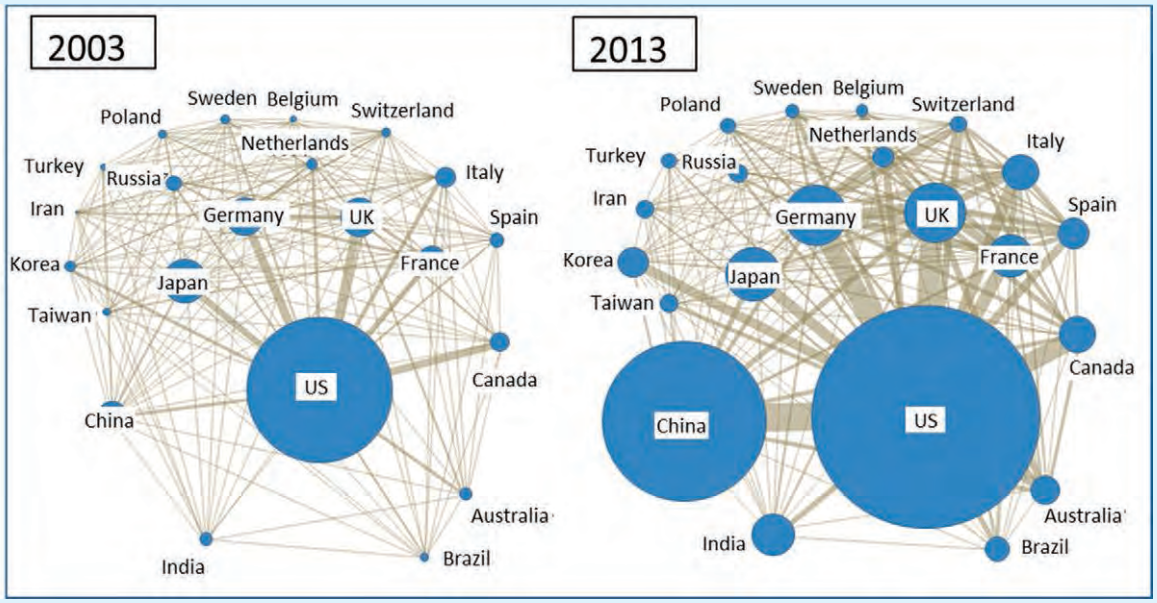
Figure 1-1-25 / International Flows of Researchers



Note: The directional line thickness depends on the number of researchers moving between two countries. "International mobility" means the number of researchers referred to in the OECD document *International Flows of Scientific Authors, 1996-2011*. The mobility between two countries is shown with a directional line when the number of researchers moving between these countries is 2,000 or larger.
Source: MEXT based on OECD, *Science, Technology and Industry Scoreboard 2013*

Trends in the number of papers published worldwide and internationally co-authored papers also suggest that scientific activities in Japan fall behind the currents of globalization (Figure 1-1-26).

Figure 1-1-26/ Trends in the Number of Papers Published Worldwide and Internationally Co-authored Papers



Notes: 1. The center of each circle is fixed in both years. The size of each circle indicates the number of scientific papers published in academic journals or in the proceedings of international conferences by researchers of the country indicated by the circle.
2. A line connecting two countries means that researchers from these countries co-authored papers, and the line thickness depends on the number of co-authored papers.
3. A co-authored paper published by researchers from two countries is counted as one paper for each country. The number of papers published by Chinese researchers has increased, and the number of papers co-authored by researchers from the USA and European countries has also increased.

Source: Created by NISTEP based on *Scopus* provided by Elsevier Co.

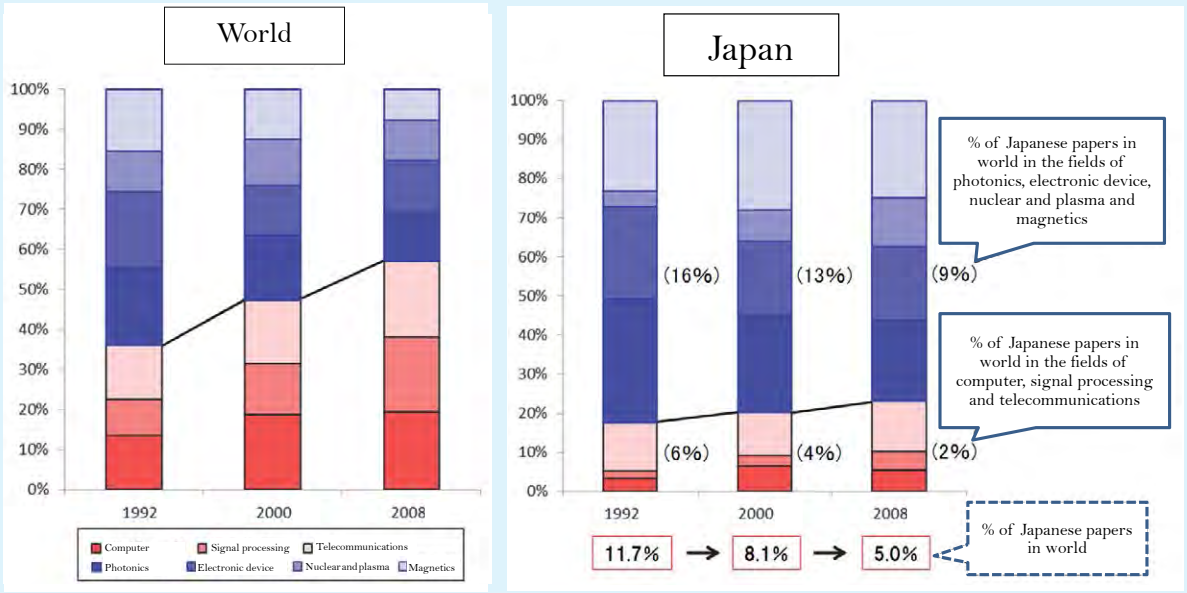
(4) Mobility of human resources across research areas

Throughout the 2000s, the percentage of each research area dealt with in the journals of the Institute of Electrical and Electronics Engineers (IEEE), one of the world's largest academic societies for electrical and electronic engineering, information and communications, changed significantly. Papers on information and communications now account for about 50% of the papers published in these journals. In contrast, the majority of papers published by Japanese researchers in these periodicals focus on device technologies (Figure 1-1-27). This suggests that Japanese researchers have not been able to flexibly modify or expand their research areas in response to changes in social and industrial needs.

This inflexibility in responding to changing social and industrial needs is also understood through the *Science Map*[1] prepared by NISTEP, which shows that Japan's contribution to research in areas that are attracting attention worldwide is smaller than those of the U.K. and Germany. There seems to be a few reasons that arise this situation; one is that those young researchers who do have a flexible mindset and high potential to excel in novel research areas have not been able to establish themselves as independent investigators. And another is that researchers are not encouraged to restudy other research areas different from their fields of expertise. For example, few researchers return to universities after they graduate in order to catch up new technologies or to obtain knowledge in other area different from their expertise. The current insufficiency of efforts focusing on future mainstream research areas in science, technology and innovation is a very serious problem.

1 NISTEP, *Science Map 2008* (May 2010)

Figure 1-1-27 / Changes in the Share of Each Research Area in IEEE Periodicals



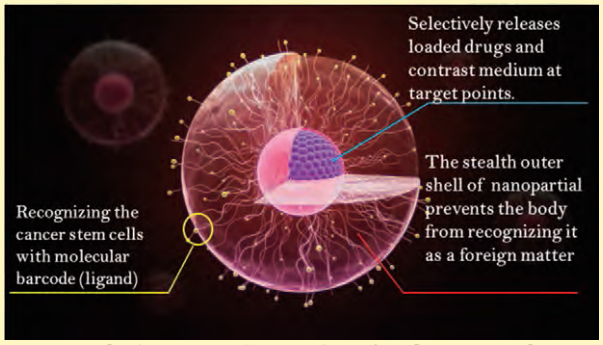
Source: NISTEP, *NISTEP Booklet ver. 2: Current Situation and Issues Regarding Research Capacity of Academia in Japan* (April 2013)

Column 1-3

One Result from the Funding Program for World-Leading Innovative R&D (FIRST) - Innovations in Diagnosis and Therapy Led by Nanobiotechnology -

Kazunori Kataoka, a professor at the Graduate Schools of Engineering and Medicine, The University of Tokyo, wWorked on developing innovative medical technologies for treatments based on nanotechnology.

Blood vessels in tumors are more permeable than normal blood vessels. Nanocapsules as small as a virus (i.e., tens of nanometers in diameter) easily accumulate in tumor cells. Prof. Kataoka developed a nano-scale technology for a new therapeutic method in which the automatic association behavior of biocompatible polymers in water is skillfully manipulated in order to carry anticancer drugs in nanocapsules that serve as "Trojan Horses" to selectively deliver the anticancer drugs to cancer cells and make them active. Refractory pancreatic cancer and difficult-to-treat brain cancers have been effectively treated using this method. This technology has been also used for advancing comprehensive cancer treatments that consist of early diagnosis, remedies and tissue reconstruction by utilizing nanocapsules to carry imaging agents or mRNA encoding differentiation-inducing factors for the purpose of diagnostic imaging of micro-cancer or tissue reconstruction. Clinical trials utilizing nanocapsules containing anticancer drugs have been conducted in many countries, including Japan and the USA, and these nanocapsules are expected to be applied in the next few years to new cancer therapy products.



A nanodevice as small as a virus for the targeted delivery of drugs and contrast agents to tumor cells to facilitate diagnosis and medical treatment

Courtesy of The University of Tokyo

3 Career Paths for Young Researchers

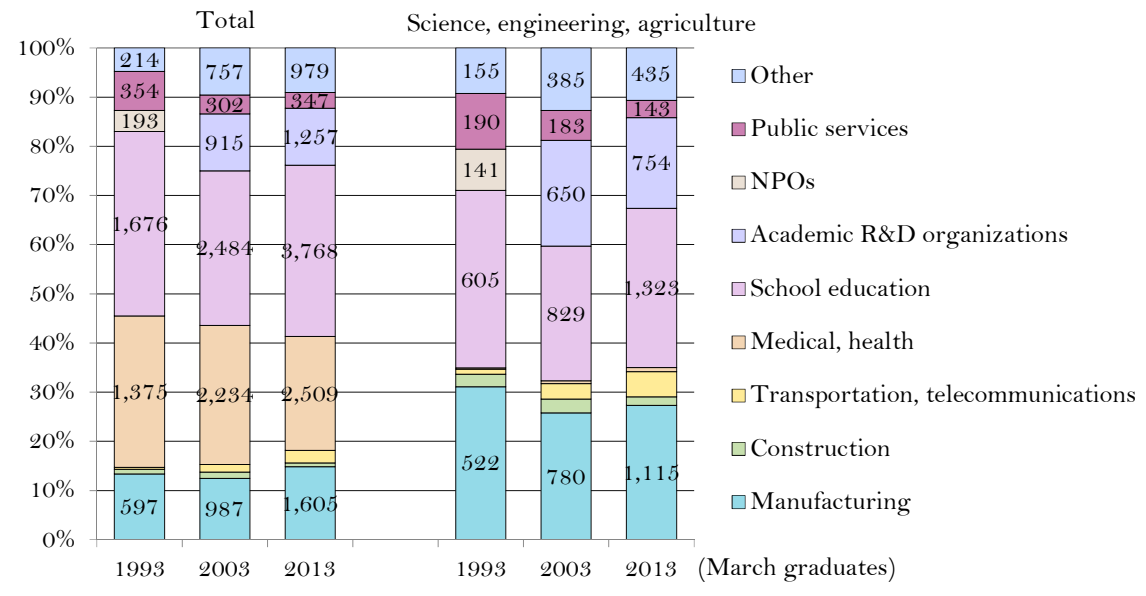
(1) Career Paths for doctoral graduates

Concerning the career paths of doctoral graduates shown in *The School Basic Survey*, the percentage of doctoral graduates who gain employment with manufacturing companies has not significantly changed

from 1993 through 2013. The percentage of doctoral graduates who become faculty members or who become engaged in school education slightly decreased from 1993 through 2013. In contrast, the percentage of doctoral graduates who have taken positions at research institutions increased in the same 20 year period, indicating that being employed in research at an independent administrative institution has been increasingly recognized as a career path for doctoral graduates.

The percentage of doctoral graduates who have taken positions at schools or research institutions has not changed significantly; the situation has remained unchanged for the past two decades, in that the majority of doctoral graduates have a research-oriented mindset and are interested in academic or research-related positions (Figure 1-1-28).

Figure 1-1-28 / The Percentage of Positions Taken by Doctoral Graduates by Industry

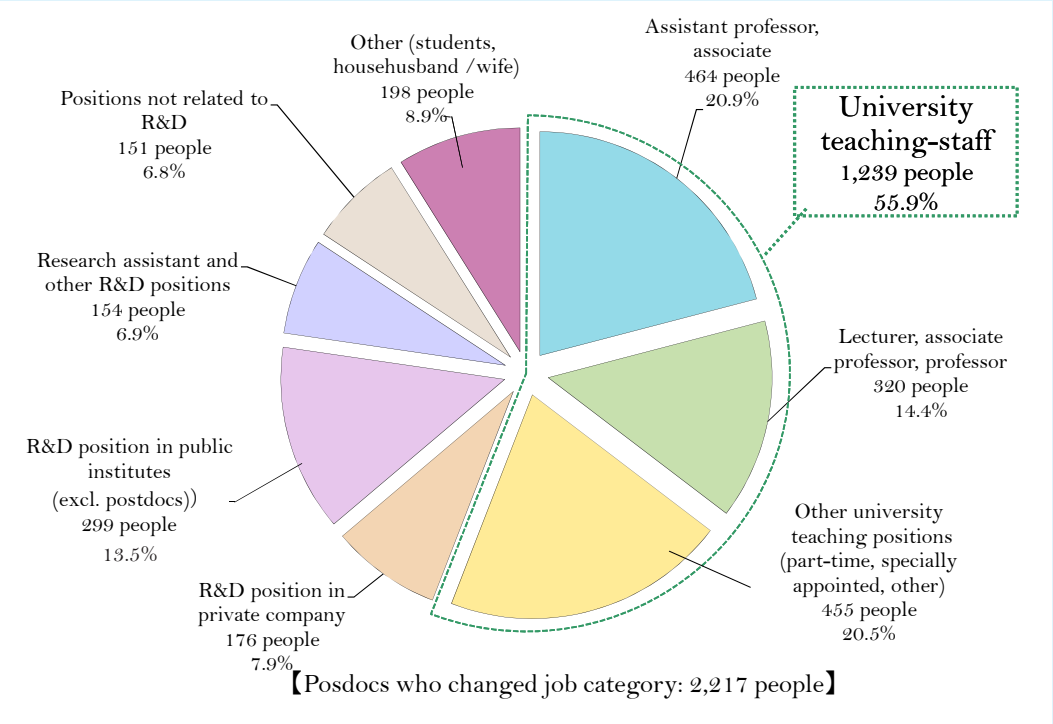


Source: MEXT based on *the School Basic Survey*

(2) Career Paths for postdocs

A survey by NISTEP (Figure 1-1-29) shows that of the 15,220 postdocs as of November 2009, 2,217 made career changes by April 2010. About 56% of these 2,217 people became faculty members, and 14% took positions at public research institutions. Only a small percentage of postdocs chose to engage in R&D in the private sector or to find a different field of work. Postdocs strongly aspire to academic positions for research.

Figure 1-1-29 / Positions Taken by Postdocs When They Made a Career Change

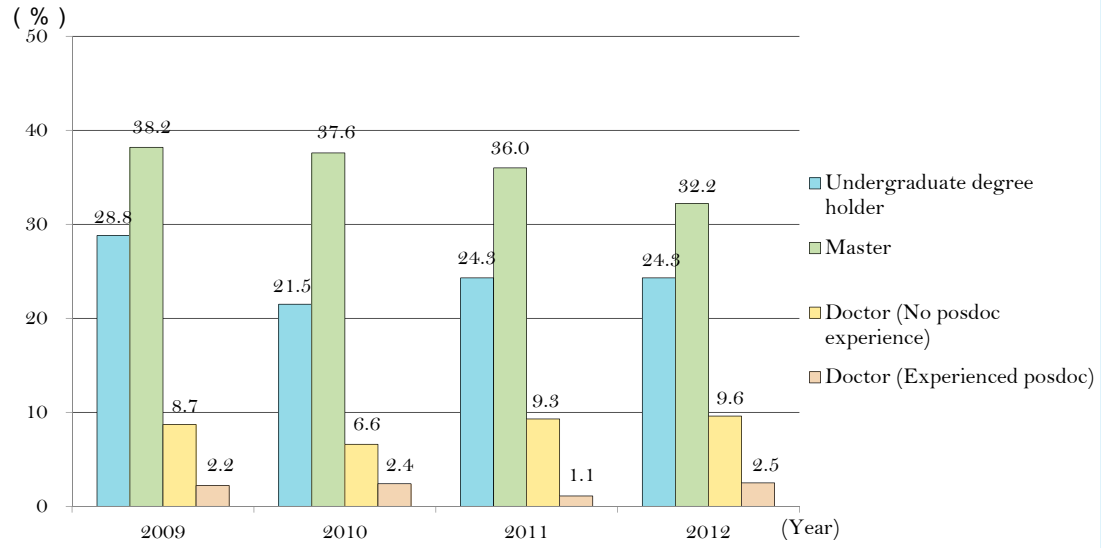


Source: NISTEP, *Postdoctoral Employment/Career Path Study*, Survey Material 202 (December 2011)

(3) Current situation regarding the employment of doctoral graduates by private companies

NISTEP conducted a survey (Figure 1-1-30) on the research activities at private companies. The survey found that 41.5% of the private companies that responded to the survey employed one or more researchers as scientists specializing in R&D in 2012; meaning that more than 50% of the private companies employed no researchers. Private companies that employed doctoral graduates, including those who had worked as postdocs, accounted for 12.1% of all responding companies. Slightly fewer than 90% of these companies employed no doctoral graduates as researchers engaging in R&D.

Figure 1-1-30 / Percentages of Private Companies that Employed Researchers for R&D

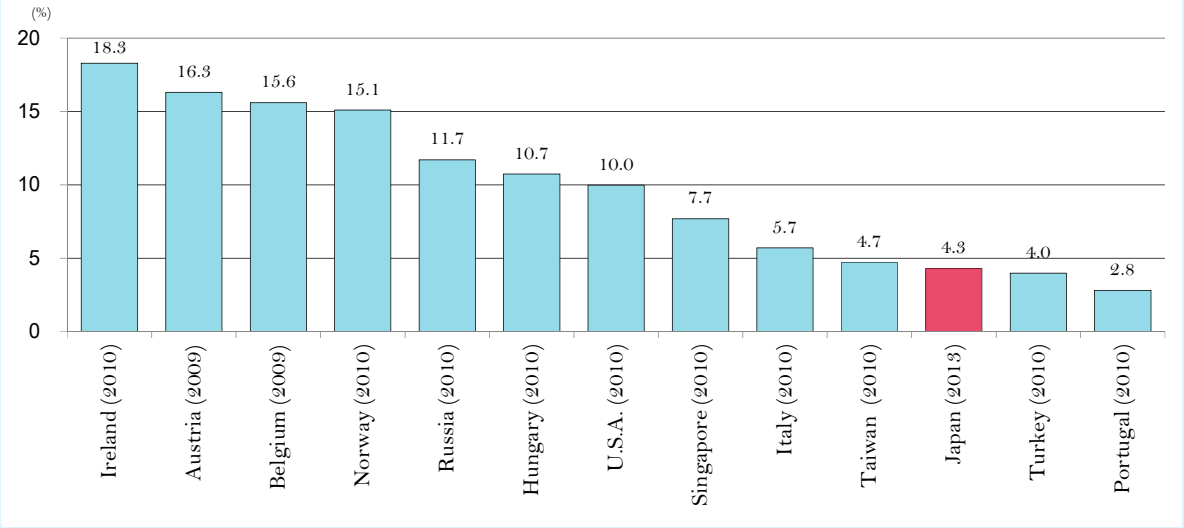


Notes: 1. The survey in 2010 was conducted on newly graduated holders of bachelors, masters and doctoral degrees.
2. In the surveys from 2009 through 2011, doctoral graduates who have not worked as postdocs and the like who have worked as postdocs include so-called "leavers without degree after fulfilling the required course."
3. The 2012 survey included doctoral graduates in doctoral degree holders, and it considered people who have worked as postdocs to be "doctoral degree holders" rather than "doctoral graduates."

Source: MEXT based on NISTEP, *Survey on Research Activities at Private Corporations*

The percentage of doctoral degree holders working as corporate researchers is smaller in Japan than in other countries. This situation presents a possible obstacle in increasing the industrial competitiveness of Japan (Figure 1-1-31).

Figure 1-1-31 / Percentage of Corporate Researchers with Doctoral Degrees

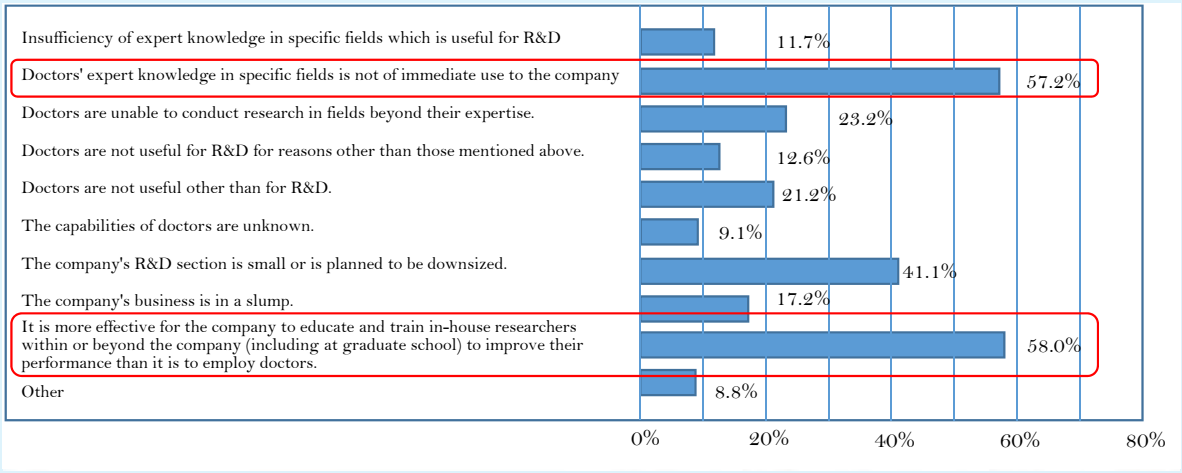


Source: MEXT based on MIC, *Survey of Research and Development 2013* (Japan), *NSF SESTAT* (the USA), and OECD, *Science, Technology, and R&D Statistics* (other countries)

As reasons for not employing doctoral graduates, many of the private companies gave responses such as "It's more effective to increase the capacity of in-company researchers by educating and training them inside and outside the company," and "Doctoral graduates have expertise in specific research areas, but they are not helpful immediately after being employed" (Figure 1-1-32). There is a tendency for private Japanese companies to focus on developing technologies independently, so have failed to join the trend toward "open innovation." They also focus on the independent development and recruitment of human resources, being insufficiently aware of the need to secure excellent human resources from inside and outside the company.

As Figure 1-1-6 indicates, there is a problem with the current situation in which Japanese corporate researchers are less willing to go back to university to raise their expertise and pursue a degree than are researchers in other countries. This problem has been partly caused by the low mobility of Japanese human resources in general. Universities and private companies are required to take proactive measures to enhance the R&D capacity of the private sector, which is the leading player in innovation in Japan.

Figure 1-1-32 / Reasons Why Private Companies Do Not Employ Doctoral Graduates as Corporate R&D Specialists

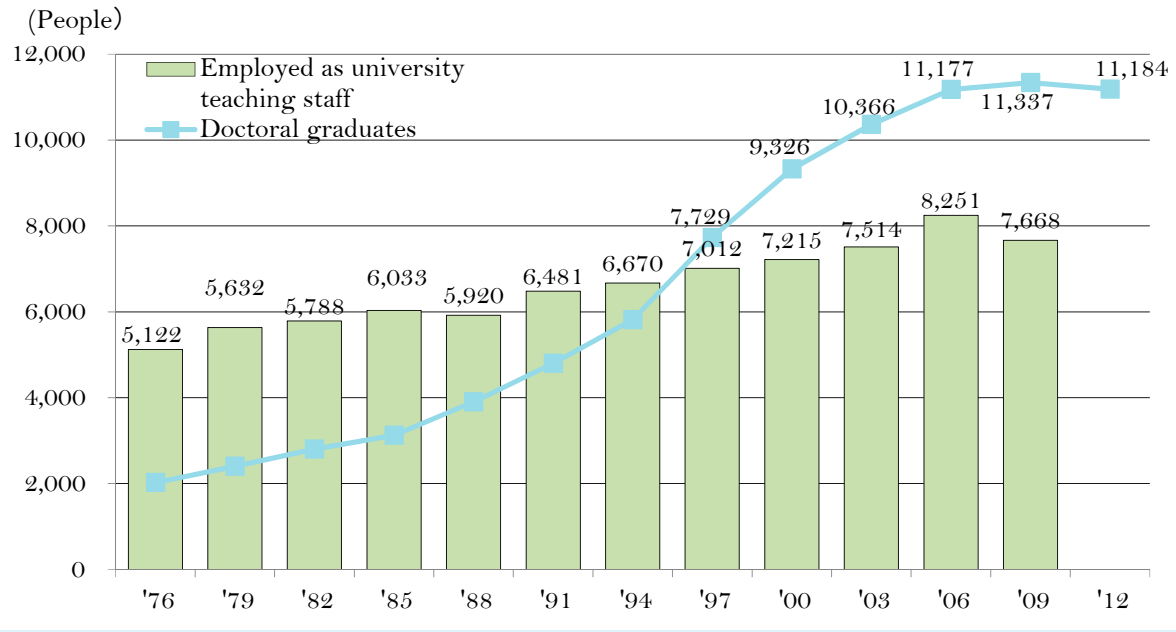


Source: MEXT based on NISTEP, *Survey on Research Activities at Private Corporations*, NISTEP Report No.155 (September 2013)

(4) Employment situation regarding young researchers

As previously stated, doctoral students and postdocs aspire to positions at universities or research institutions, and private companies are unwilling to employ doctoral graduates. Opportunities for positions as key faculty members are limited. The number of doctoral graduates far exceeds the number of faculty positions that are available to doctoral graduates, and this discrepancy has increased in recent years (Figure 1-1-33). Particularly with regard to the employment situation of faculty positions younger than 40 years old, 5,835 people, or only half of the 11,337 doctoral graduates, were newly employed in FY2009 as faculty positions specializing in science, engineering, agriculture or health.

Figure 1-1-33 / Changes in the Number of Doctoral Graduates and in the Number of Newly Employed Key Faculty Members in the Fields of Science, Engineering, Agriculture and Health



Note: Regarding 2009, for example, the number of newly employed key faculty members refers to the number for FY2009, and the number of doctoral graduates refers to the number of students who completed a doctoral course in March 2009.
Source: MEXT based on *the School Basic Survey* and *the School Teachers Survey*

Many of the postdocs who take positions as faculty members or researchers at independent administrative institutions are employed under fixed-term contracts. A survey conducted by NISTEP shows that 37% of postdocs and the like who made a career change took a different position under fixed-term contracts (Table 1-1-34). Concerning the postdocs and others whose contract terms are known, fixed-term contracts account for 52% of all their positions and account for 66% of their positions as faculty members.

Table 1-1-34 / Term of Office of the Postdocs and the Like after Making a Career Change

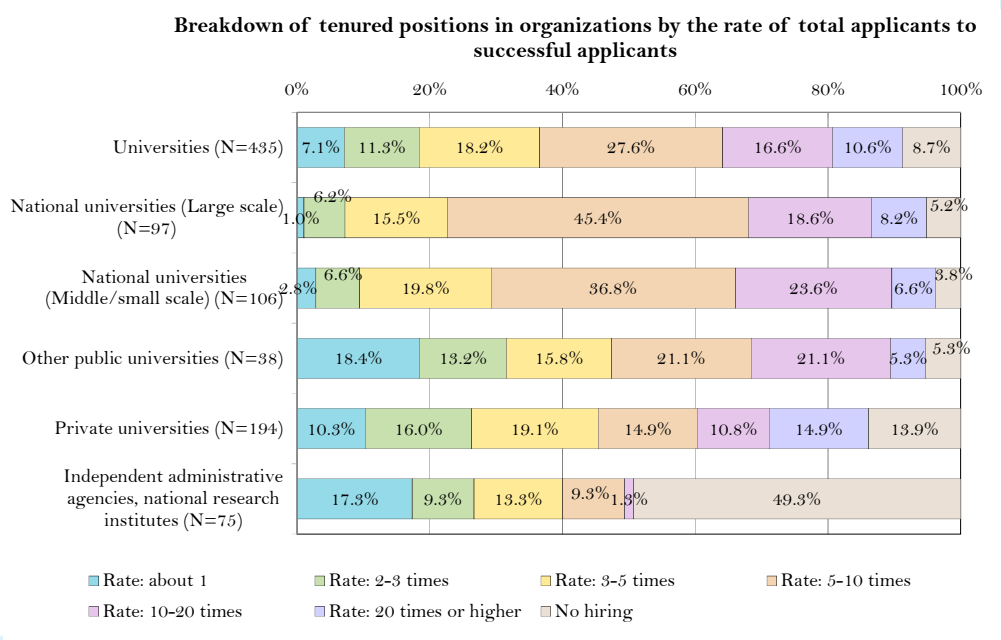
New careers		Tenured	Non-tenured	Not applicable	Uncertain weather tenured or not	Total
University teaching staff	Assistant professor, associate	250	119	0	95	464
	Lecturer	33	84	0	53	170
	Associate professor	24	67	0	38	129
	Professor	4	10	0	7	21
	Other university teaching-staff (incl. part-time or specially appointed position)	282	30	0	143	455
R&D position in a private company		0	176	0	0	176
R&D position in a public research institution		91	166	0	42	299
Research assistant or other R&D positions		92	15	0	47	154
Other than R&D position (Education-related, jobs that require specialized knowledge)		31	47	0	30	108
Other than R&D position (public officer, staring and managing business, clerical work, other)		9	28	0	6	43
Other (incl. student, housewife/husband)		0	0	198	0	198
Total		816 (36.8%)	742 (33.5%)	198 (8.9%)	461 (20.8%)	2,217 (100.0%)

Source: NISTEP, *Postdoctoral Employment/Career Path Study*, Survey Material 202 (December 2011)

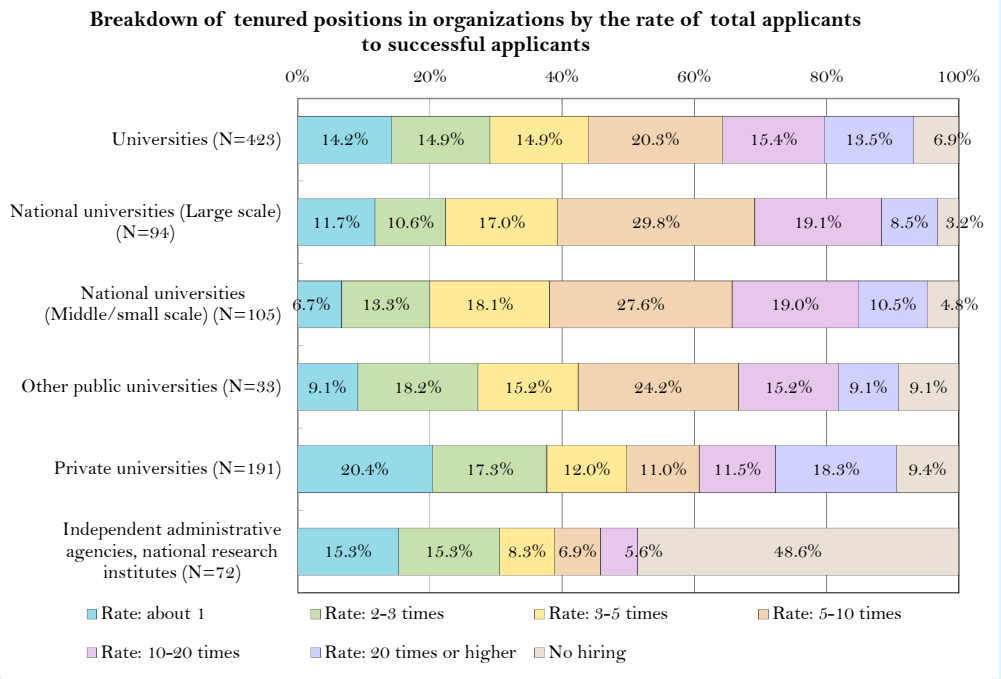
In light of these circumstances, it has become more difficult for young researchers to obtain tenured positions. Finding a research position or a tenured position at a university or research institution is a highly competitive experience. Fewer than one in ten applicants succeed in finding a position at a university as a professor or associate professor (Figure 1-1-35).

Figure 1-1-35 / Rates of Total Applicants to Successful Applicants for Tenured Positions

Director, chief, professor



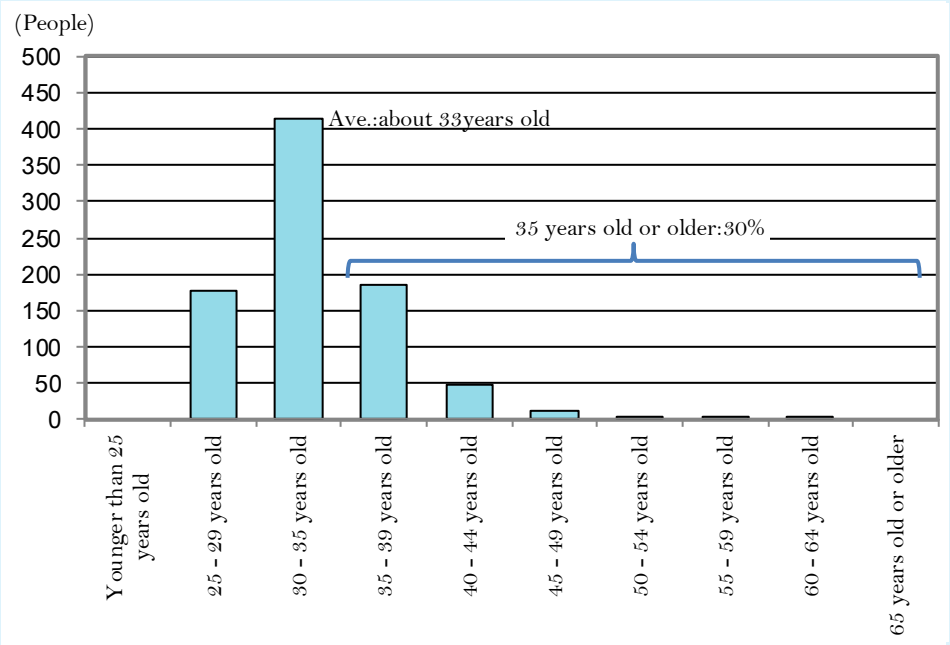
Group leader, associate professor



Source: NISTEP, *A Survey about Mobility of Researchers and Diversity of Research Organizations, NISTEP Report No.123* (March 2009)

The Survey on Staff Statistics shows data on career paths for young researchers, particularly on career paths for postdocs. According to that survey, postdocs and others who were employed as key faculty members in FY2009 were 33 years old on average, and about 30% of them were 35 years of age or older (Figure 1-1-36). A NISTEP survey[1] shows that the average time spent at each position for postdocs is 2.7 years, and it is assumed that these postdocs take postdoc positions multiple times before securing positions as key faculty.

Figure 1-1-36 / Age Distribution of Postdocs Employed as Key Faculty Members (FY2009)

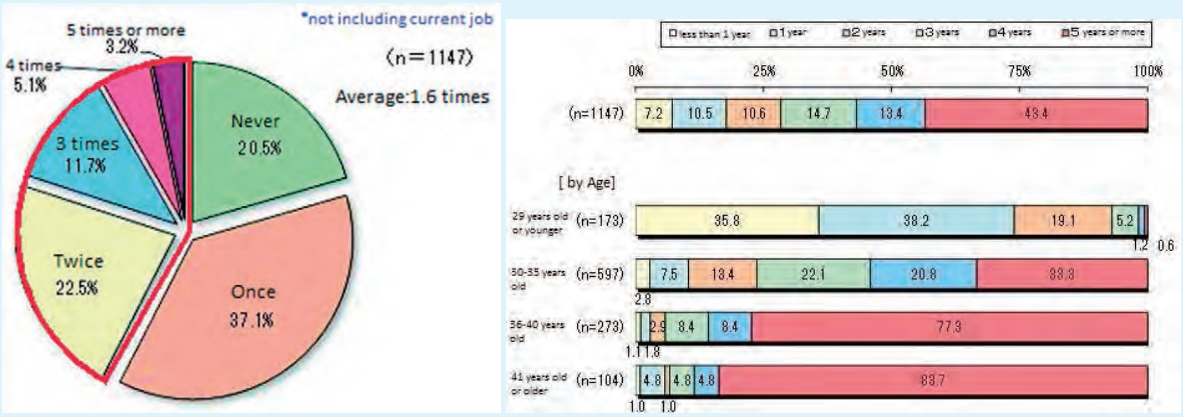


Source: MEXT based on *the School Teachers Survey*

1 NISTEP, *Survey on Research Activities and Attitudes of Postdoctoral Fellows, Survey Material 159* (October 2008)

A questionnaire survey (Figure 1-1-37) of researchers specializing in life sciences who are in postdoc or other positions under fixed-term contracts shows that over 40% of these researchers took a position under a fixed-term contract three or more times. The people who have been in a position under a fixed-term contract for five or more years account for 77% for the 36-40 age bracket and 84% of those 41 years of age or older. About 40% of the postdocs specialize in life sciences[1], and many of them take positions as postdocs multiple times. The results indicate that the current situation is caused not merely by the high mobility of these postdocs, but also by the unstable employment situation they face.

Figure 1-1-37 / The Number of Postdoc Positions Held by Each Researcher under Fixed-term Contracts, and the Total Years under Fixed-term Contracts by Age



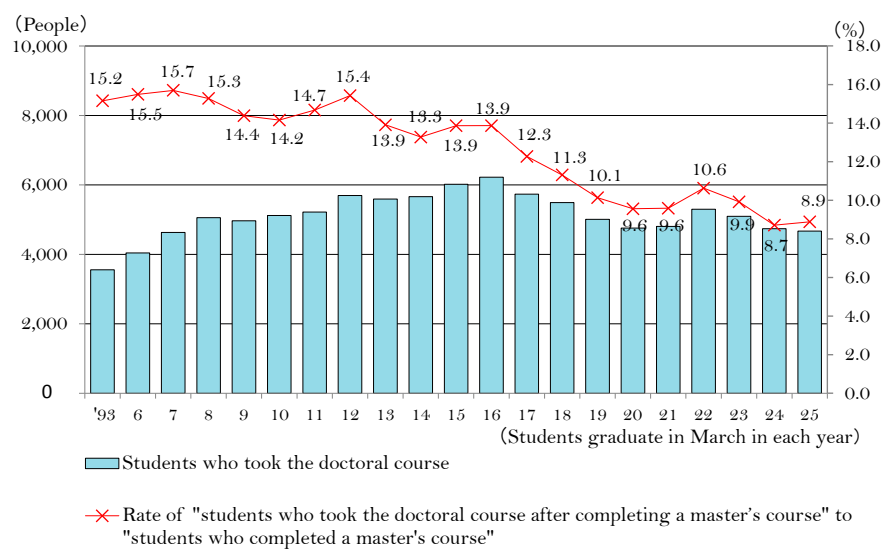
Source: Committee on Basic Medicine, Science Council of Japan, Recommendation, *Current Situation and Issues Regarding Postdoc/Assistant Professor/Associate Positions under Fixed-term Contracts in the Field of Life Sciences* (September 29, 2011)

1 MEXT, *Survey on Postdoctoral Fellows and Research Assistants (FY2006)* (August 2008)

(5) Doctoral students in Japan

In light of the circumstances described previously, the number of students majoring in natural science who took a doctoral course after completing a master's course[1] peaked in FY2004 and has been decreasing since then. Of the students who earned a master's degree in March 2013, 4,669 went on to take a doctoral course. This is approximately 75% of the figure for 2004 (Figure 1-1-38).

Figure 1-1-38 / Changes in the Number and Percentage of Students Majoring in Natural Science Who Took a Doctoral Course after Completing a Master's Course

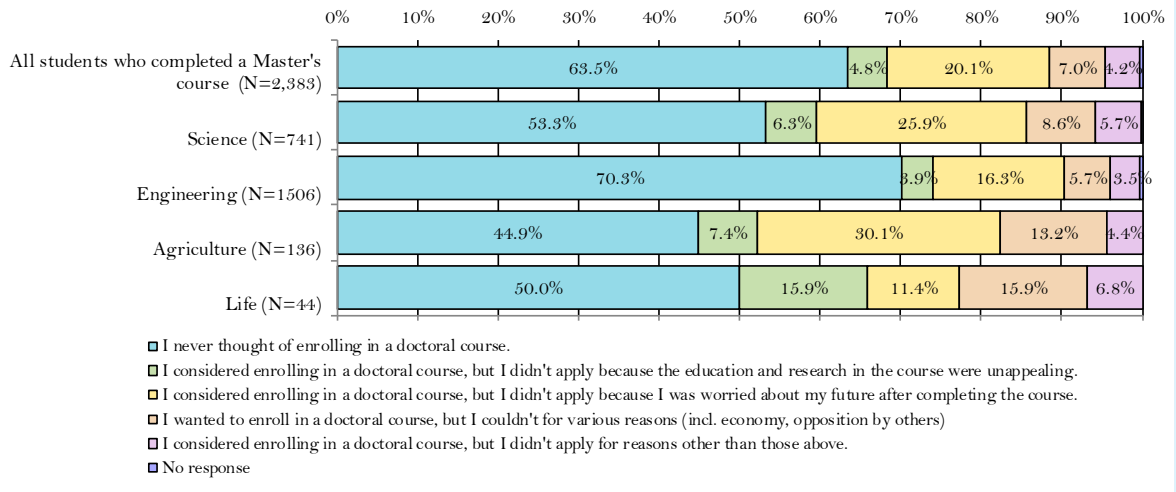


Source: MEXT based on *the School Basic Survey*

A survey conducted by the Cabinet Office in March 2010 (Figure 1-1-39) shows that uncertainty over the future is the main reason students, who might have chosen to pursue doctoral studies, ended up not pursuing those studies.

1 In Part 1, "master's courses" refers to master's degree programs and to the two-year first term of doctoral programs (including the first and second year of the five-year program for the doctoral course), unless otherwise annotated.

Figure 1-1-39 / Reasons Why Students Did Not Choose to Pursue Doctoral Studies

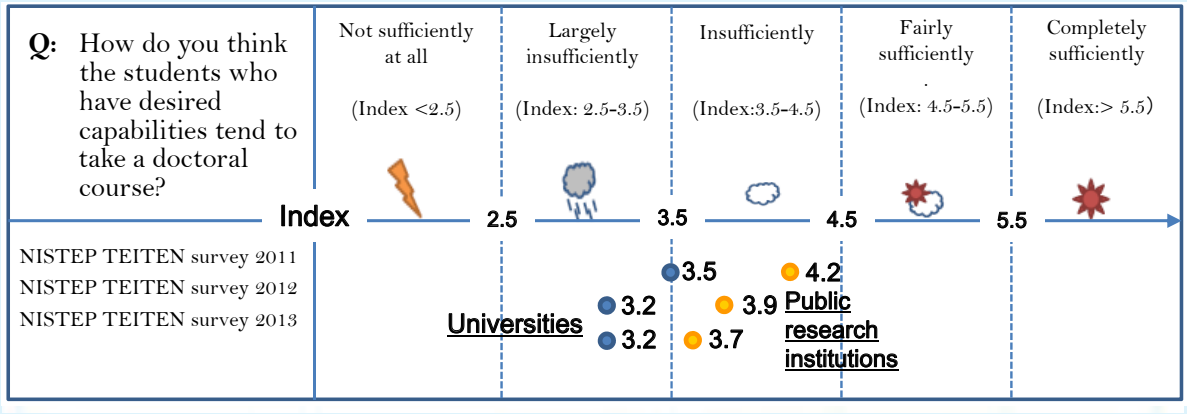


Note: The total number of students who have completed a master's course does not include those majoring in life sciences.
Source: Cabinet Office, Government of Japan, *Basic Survey for Examining Enhanced Development of Human Resources in Advanced Science and Technology* (March 2010)

According to a NISTEP TEITEN survey, it is generally recognized that not all students who are fully qualified to pursue a doctorate are willing to take a doctoral course, because of the anticipated difficulty in finding employment, anxiety about their career paths and economic reasons (Figure 1-1-40).

These survey results suggest that students holding master's degrees are unwilling to pursue a doctorate chiefly because postdoctoral students face employment insecurity, including a scarcity of opportunities to gain employment in academia or industry, and because they have concerns over economic insecurity during and after the doctoral course.

Figure 1-1-40 / How do you think the Students Who Have Desired Capabilities Tend to Take a Doctoral Course? (Expert Survey Results)



Source: MEXT based on NISTEP, *Expert Survey on Japanese S&T System and S&T Activities by Fields (2013 NISTEP TEITEN survey)* (April 2014)